

The 50 MHz DX Bulletin

Volume 3

1992 September

Issue #9

The 50 MHz Bulletin was founded by Harry Schools KA3B. Until May 1993, Shel Remington N16E/KH6 was its editor-in-chief, and I, Victor Frank, K6FV, its publisher. Shel sent only one issue after August 1992, and I have felt it my place to take over and fulfill the subscriptions. This is the first of a half dozen pre-dated "fill-in" issues that will be sent during the remainder of 1993. The 50 MHz Bulletin is dedicated to the understanding and utilization of long-distance propagation in the 6-meter amateur band. This bulletin may be freely quoted, provided that credit is given. The publisher's address is 12450 Skyline Blvd, Woodside, CA 94062-4541.

Mailbox

TransEquatorial Propagation

Dear Victor, from Hal Lund, ZS6WB 23 June 1992

Six meters has totally died here with Europe last heard on 05 May (92) (worked ES6QB for number 89) and a five minute African opening on 30 May when I worked D68BR (unfortunately not a new one). Worked only a few local stations since that time.

This year our expected peak DX season during the last weeks of April just didn't appear. During the same period last year we had the only openings of the cycle to South America as well as JAs and VKs. In 1992 nothing, there was little else but a bit of TEP into the Mediterranean. By the time the European Es season had begun, even the TEP had died down here, so we had none of the combined TEP + Es that we need to get into the northern European countries.

We're seeing what we saw in 1988 in reverse. For almost a full year, stations a few hundred miles north of us had propagation on six while here in South Africa we heard nothing. Then, in 1989, it opened to those of us in northern South Africa and a year later the openings also occasionally extended down to the southern part of the country.

Now the southern edge of the propagation belt is moving north again and while it has been totally dead here, stations in Malawi, Botswana, Zimbabwe and Namibia have continued to have openings. I expect we might have a bit of TEP to the Mediterranean in September-October, but if solar activity remains low, we have probably seen the last of the east-west openings here until Cycle 23. Guess I must be grateful for the DX we have gotten, certainly more than I expected at the start of the cycle.

Hal Lund, ZS6WB, P.O. Box 27746, Sunnyside, Pretoria 0132, REPUBLIC OF SOUTH AFRICA

Hal's letter reminded me that most of us 6m operators do not appreciate the differences between 6m propagation experienced at different spots over the world.

Perhaps if we knew more about this we'd be a little smarter about choosing not only **where** to go on a DX-pedition, but **when**!

When 6m amateurs find they can communicate (or hear beacons) from somewhere over half the days during a given month, they may assume that since it is no longer a new country, it is no longer newsworthy.

To the erstwhile 6m DXer yearning to break free of the snows of New England, or to go on Spring Break to somewhere warmer, the seasonal geographical vagaries of 6m propagation are very important. Should he take his 6m station along, perhaps to some deserted island, perhaps for weeks or months? Or should he just forget about it?

I had some inkling of propagation between Tahiti and Hawaii, but what about South America, Africa, and Asia? What better way to find out than to write some of our distant subscribers?

50 MHz DX Bulletin

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2 March 1993

CALL FOR VHF LOGS, SPRING 1993

Dear Six Meter Enthusiast,

You don't need me to tell you that six meter propagation is **down** compared to the last few years. But I don't think it is time to put your rig into storage.

I am writing this letter to a couple dozen of you thought to be active and close enough to the magnetic equator to experience Trans-Equatorial Propagation, TEP for short. The equinox, and TEP season is fast approaching. I suspect that 6 mtr hams in South America and the Far East may have communicating via TEP already this season, but the west coast USA-south pacific path typically doesn't open for another month.

And what of Sporadic-E? We in temperate latitudes experience that propagation most frequently in summer, when the sun is most nearly overhead. When does Es peak near the equator? During the equinoxes?

Would you please send me loggings of what you are (have been) hearing on frequencies above 45 MHz the past and next two months. What I am especially interested in is regular observations (both positive and negative) listing beginning and ending times of stations which you hear, for example in the form of the TEP Observations that I published on the back page of the 50 MHz DX bulletin. Also helpful are beam directions (if not direct), and signal reports.

There are plenty of beacons and commercial stations of opportunity to monitor, but I would also encourage you to transmit, especially near 50.110 MHz during evenings (18-24 hours local) until other stations are noted. Don't be discouraged by lack of activity on 10 mtrs! Don't be shy, but do listen as well!

Let's see what can be worked during these coming months of declining solar activity!

Bob, K6QXY, sent me a copy of an article by Ken Neubeck, WB2AMU, that appeared in March 1993 WorldRadio that illustrated "not being clear on the concept" of solar-terrestrial geometry. In it, Figure 3 showed the earth and sun with parallel equators and the earth looping somehow between $-23\frac{1}{2}^\circ$ and $+23\frac{1}{2}^\circ$ solar latitude. It didn't work that way in 1969, when I wrote in January 1969 *ham radio* that the axis of the sun was inclined 7° to the ecliptic (the earth's axis is inclined $23\frac{1}{2}^\circ$). Cary Oler explains it a little better in Part II of Understanding Solar-Terrestrial Reports (on page 6), which is continued from our July 1992 issue.

I did a little soul-searching about including what comes first this month, the remainder of Part I. Just how the effect of solar flares on the atmosphere relates to 6m propagation is a bit nebulous. Still, for completeness' sake (and some of you may be interested in the atmosphere), I have included it. And so, with no further introduction:

6.2.1. Atmospheric Pressure Responses to Solar Flares

A pronounced cellular structure of pressure change was discovered by Schuurmans[12], who calculated the difference in the 500 mb height before and after a major flare. A total of 53 cases were originally studied, which was later expanded to 81 cases by Schuurmans and Oort.[13] The flare threshold level was chosen to be of optical class 2B or greater. Flares of class 2B or greater were therefore included in this study. Data from 1020 observation locations were used to provide coverage of most of the northern hemisphere. Regions of increased 500 mb height rise were observed near the longitudes 50W, 115W, 150W, 165E, 135E, and 5E. Height decreases were observed near 35W, 175W, 145E, and 85E. The most pronounced changes were areas in the middle latitude zones (40° to 60°) with cellular groupings most apparent near the coastal regions. The height differences were observed to be mostly negative poleward of about 70° latitude.

The apparent cellular structure of pressure change following major solar flares was also detected in studies performed by Duell and Duell.[14] Using data collected by Duell and Duell, Schuurmans and Oort performed a critical statistical analysis on the accumulated data and concluded that "the central values in the main areas of height fall and height rise are probably meaningful and thus not due to pure chance."

Schuurmans and Oort continued with an analysis of the pressure changes which occurred in the vertical plane before and after major flares of class 2B or greater. They found that maximum flare response was found to occur at the 300 mb level, at least along the 60° north latitude parallel between longitudes of approximately 0° to 70° west. The greatest average change of $+4.7$ gpdm was found at the 300 mb level over the North Atlantic by a ship positioned at 56.6 N, 51.0 W. At higher elevations, maximum response was noted to occur approximately six hours after flare time. At the Earth's surface (approx. 1000 mb), the atmospheric changes lagged the flare time by about two days.

Along with the pressure-height changes which were observed over the North Atlantic regions, a fairly significant change in the vertical temperature distribution was also observed over these regions. A maximum change of near $+1.1$ degrees Celsius was observed at the 500 mb level, and a maximum decrease of about -1.8 degrees Celsius was observed at the 200 mb level. The strongest

temperature gradients were observed near the 300 mb level where the change in pressure was greatest.

The speed of the geostrophic wind flow increased notably at the 500 mb level in latitudes from 55° to 75° north by about 0.5 m/s. Near the 50° north latitude zone, a decrease in geostrophic wind flow by about 0.4 m/s was observed.

Seasonally, the cellular structure which was found by Schuurmans and Oort changes very little. However, the largest changes in height were found in the winter and the smallest changes were observed during the summer.

Considering the large changes in pressure at the 8 km height level down to the surface over the North Atlantic, formed after major flares, one would expect a mass transport of air downward.

In an attempt to determine the validity of this hypothesis, Reiter[15] measured the concentrations of tracer elements Be^7 and P^{32} at Zugspitze, which is located at an elevation of 2.96 km. He found significantly increased concentrations of these elements on the second day following major flares of importance 2B or greater. According to Reiter, these two radioactive nuclides are formed in the stratosphere by cosmic ray spallation and their increased concentrations at Zugspitze is an indication of a mass transport of stratospheric air. Reiter noted that the possibility of increased concentrations of the tracer elements at Zugspitze was not likely to have been generated by in situ production by enhanced solar cosmic ray fluxes associated with the flares, because the production rate would be orders of magnitude too small to explain the observed nuclide concentrations. Furthermore, he noted that the maximum concentrations coincided with maximums in solar wind velocity and geomagnetic activity following the larger flares. This coincides nicely with the average arrival time of large interplanetary shockwaves for major flares of class 2B or greater.

6.2.2. Atmospheric Electrical Enhancements following Major Flares

Observations and measurements of atmospheric electrical properties were made during 70 major flares between 1956 and 1959 by Reiter.[16] Other investigations have been performed by Holzworth and Mozer[17], Bossolasco et al.[18] [19], Markson[20], Herman and Goldberg[21] [22], Cobb[23], and Reiter.[24] [25]

Reiter, at the Zugspitze observatory, found that both the potential gradient and the air-earth current density increased beginning shortly after a major flare. The values peaked between 3 and 4 days after the flare.

Measurements conducted by Cobb on Mauna Loa mountain in Hawaii a few years earlier indicated a sharp increase in both the potential gradient and the air-earth current density following solar flares and remained above normal for several days thereafter. Cobb's peak in potential gradient occurred at about the same time as Reiter's, 3 to 4 days after the major flares, but his air-earth current density peaked only one day after the flare.

It should be noted that these observations, by Reiter and Cobb, were performed at altitudes above the mixing layer where the potential gradient and air-earth current densities do not undergo any large, localized fluctuations. Therefore, variations in these two parameters should reflect changes on a global scale.

The atmospheric electrical changes which appear to occur after solar flares leads to the question of whether the occurrence of lightning frequency increases after a solar flare. With respect to this, Reiter noted a 57% increase in sferics counts maximizing about 4 days after flare-day during the years 1964 to 1967. When compared to Reiter's results regarding the potential gradient over these same years, it is found that the magnitude of increases in sferics counts and in the potential gradient are comparable.

Markson (1971) analyzed the occurrence frequency of thunderstorms with solar flares in the United States for the sunspot minimum years 1964 to 1965. He found a 63% increase in occurrence frequency maximizing about 7 days after flare eruptions. He pointed out that his maximum in the U.S. occurred about 3 days after the maximum in potential gradient found by Reiter at Zugspitze. This long lag time therefore makes it uncertain (at least, based on these results), whether United States thunderstorm activity is affected by solar activity the same as in the regions observed by Reiter.

On a global basis, Bossolasco et al. found that thunderstorm activity increased by 50% in solar minimum years and by 70% in solar maximum years about 4 days after flare eruptions. The frequency of lightning strikes in the Mediterranean area was observed to increase markedly about 4 days after the eruption of large solar flares. Through superposed epoch analysis of the data in the foregoing, it has been established that the occurrence frequency begins a notable increase one day after the flare event and achieves a 50% increase on the 4th day. These results are in good agreement with those obtained by Reiter at the Zugspitze observatory.

Data analyzed over a full solar cycle (between the years 1961 and 1971) exhibited the same results, as determined by Bossolasco et al. (1973).

From these results, it appears that the air-earth current density, ionospheric potential, potential gradient and the frequency of lightning strikes responds to solar flares. Enhancements in these quantities occur between 1 and 4 days after the flare eruption with the increase in lightning frequency responding the slowest.

A suggested possible physical mechanism lies in the increased potential gradient around the 20 km altitude level. High energy solar protons ejected from major flares penetrate the atmosphere down to levels as low as 20 km. The increased ionization at these levels (during intense events) enhance the conductivity above about 20 km. Below 20 km, Forbush decreases in cosmic ray intensity results in decreased conductivity. The potential gradient and ionospheric potential are also altered and the net result is a possible increase in thunderstorm activity.

6.2.3. Geomagnetic Effects on Atmospheric Pressure

Based on an analysis of low-pressure trough development at the 300 mb level in the North Pacific and North America areas for the years 1956-1959, Macdonald and Roberts[26] found that, in the winter seasons, 300 mb troughs entering or forming in the Gulf of Alaska area 2 to 4 days after a major geomagnetic storm are likely to undergo much greater deepening than those entering at other times. Macdonald and Roberts[27] as well as Twitchell[28] verified that these conditions are also manifest at the 500 mb level.

Roberts and Olson[29], using a vorticity area index (VAI), extended these earlier results. They defined the VAI as the area of a trough wherein the absolute vorticity was greater than or equal to $20(10^{-5})/\text{second}$ summed with the area where it is $24(10^{-5})/\text{second}$. This index removes the subjectiveness from the assessment of the intensity and importance of troughs and the minimum threshold vorticities for the definition were selected as such because most wintertime 300 mb troughs exceed a vorticity of $20(10^{-5})/\text{second}$, and large ones have a substantial region exceeding the largest vorticity value.

The results obtained by Roberts and Olson confirmed the earlier findings of Macdonald and Roberts. Using data spanning the years 1964 to 1971, Roberts and Olson found that there are two statistically significant periods of time when key troughs undergo a sharp rise in vorticity area index. The first occurs during the first three days of trough lifetime. On the average, this occurs three to five days after the start of a geomagnetic storm. It is important to note that their findings showed that 2 to 4 days must elapse between the beginning of a geomagnetic storm and the appearance of the trough in order for the effect to be observed. On occasions when less than 2 days elapsed, no VAI intensification occurred (as was later discovered by Olson et al.[30]). The second statistically significant period of time where troughs undergo significant increases in VAI occurs about 10 days after geomagnetic storms. Asakura and Katayama[31] also discovered significant decreases in pressure and increased cyclogenesis over north-eastern coastal regions of North America.

Reitan[32] noted, after analyzing data over the 20-year period 1951-1970, that the distribution of cyclonic event occurrence in January over the northern hemisphere exhibited a maximum in the areas of the Gulf of Alaska and the northeastern coastal region of the United States. These are also the areas where Roberts and Olson found increases in VAI following geomagnetic storms. A correlation analysis was performed to analyze the association of SSC-related geomagnetic storm occurrences and the number of cyclonic events observed in the United States over the period 1951-1967, by Mayaud[33]. What was discovered was a statistically significant (94% confidence level) correlation coefficient of -.46 between SSC-related geomagnetic storms and the number of cyclonic events observed in the U.S. during the period. These results, combined with those of Roberts and Olson, suggest that, although fewer cyclonic events may occur during the sunspot maximum years, they are larger and more intense than the more numerous ones that form in the solar minimum years.

From the data which has thus far been accumulated, it appears as though the strongest meteorological effects of solar flares and geomagnetic storms occurs during the winter season in the northern hemisphere. Although the data contained in this document just barely scratches the surface of research which has been done over the years, there are still doubts whether a solar or magnetic link to terrestrial atmospheric circulation patterns actually exists. It is our impression that such a link may indeed exist, but additional research is needed in order to determine the areas and physical mechanisms which link solar and/or geomagnetic activity to specific atmospheric events. Nevertheless, the research data which has accumulated over the years cannot be dismissed, for there are a great many relationships between solar activity, geomagnetic activity and atmospheric phenomena which appear to have strong correlations.

Those persons with sufficient background who are interested in obtaining more information regarding the possible influences of solar activity on terrestrial atmospheric processes, are directed to obtain the book "Sun, Weather, and Climate" by John R. Herman and Richard A. Goldberg (formerly published as NASA SP-426 but recently republished by Dover Publications Inc. in book form). This document nicely summarizes most of the research which has been done in this area over the years and provides some convincing evidence between solar, geomagnetic and atmospheric relationships. For more recent information, the interested reader is encouraged to browse through the various journals covering this subject and the published results of numerous solar terrestrial workshops and symposiums.

7. Concluding Remarks

There are many aspects of solar physics and geophysics (not to mention atmospheric physics) which must be understood before a clear knowledge of the interactions between solar activity and terrestrial phenomena can be obtained. This document was prepared to aid in providing the most basic and fundamental characteristics of solar activity and geophysical phenomena required to understand and respect the nature of the solar terrestrial reports which are posted over the networks.

This document was intended to be understood by those who are unfamiliar with solar terrestrial physics. The solar terrestrial reports posted over the networks are in as simple a form as is practical without losing any significant resolution of information. They are written in a form that should be easily understood once the basic principles and language become familiar.

The preceding presentation was required in order to supply the interested reader with the information and language background to understand the solar terrestrial reports. Only the latter sections were directed towards those with an interest and background in geophysics and atmospheric physics. The rest of the material should have been interpretable by those whose backgrounds and/or interests lie in other areas.

This document is not intended to be fully understood the first time through. It should be reread and digested as necessary and used (if necessary) as a reference to the solar terrestrial reports.

Now that we have the background necessary to understand the solar terrestrial reports, we may begin a systematic analysis of the structure and content of the reports themselves. The accompanying document (part II) will describe the solar terrestrial reports in detail with accompanying hints and procedures that may be used to extract useful and pertinent information.

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Understanding Solar Terrestrial Reports Part II - Interpreting the Reports, Rev. 1.2

Abstract

Part I of this document discussed the morphology of solar and geophysical phenomena. With this background now in hand, a discussion of the solar terrestrial reports themselves can begin. The purpose of this document is to explain the meaning of the various sections of the Solar Terrestrial Forecast and Review which are posted over the networks on a weekly basis. In addition, the purpose and application of the other reports, alerts and warnings will be discussed. After having digested the material in parts I and II of this document, the interested reader should have enough background and knowledge to begin actively applying the information in the reports. The reader is encouraged to digest part I of this document first (In our May and July 1992 issues).

1. Introduction

The solar terrestrial reports posted over the networks presently consist of several reports, alerts and warnings. The Solar Terrestrial Forecast and Review is the only regular weekly publication. It contains a summary of conditions which occurred over the preceding week and includes forecasts for the next 10 to 20 days. This report is the one

which will be concentrated on most heavily in part II of this document. It contains most of the data, forecasts and charts required and used in practical applications.

The Major Solar Flare Warning is a brief message which is posted over the nets when a major flare (or flares) may be possible. These messages are only sent when regions on the solar surface are complex and threatening enough to produce potentially major energetic activity. They are therefore only intended to alert people to the increased potential for major flare activity.

A Major Flare Alert is posted whenever a major energetic flare erupts on the sun (of class M5.0 or greater). Such an alert include a description of the event and any outstanding accompanying phenomena (ex. sweep frequency events, abnormally high radio bursts, etc.). If the flare could have a terrestrial impact, an impact assessment is given within the body of the alert message.

The Major Geomagnetic Storm Alert is posted whenever geomagnetic conditions reach storm levels over middle latitudes. These alerts are not posted when storm conditions may exist for high latitudes, because high latitudes experience a significantly greater number of magnetic storms than do the lower latitudes and fewer numbers of people are affected by the high latitude storm periods than middle latitude storms.

We begin our discussion of the solar terrestrial reports with an analysis of the solar terrestrial review section of the reports. We will attempt to cover the language used and discuss the format of this section of the reports. Following this, we will continue with a discussion of the Monthly Solar Terrestrial Review followed by a discussion of the Geomagnetic Storm Alerts. The Major Solar Flare alerts and warnings should be more easily understood after this document has been digested.

The interested reader may need to re-read parts I and II of this document before acquiring a clearer understanding of these reports and their applications. A great deal of material is covered in this document and may not be fully understood the first time through. Application of these reports to the various inter-related fields may require practice and persistence in order to understand the impacts of certain events on specific terrestrial systems (such as radio communications). The interested reader is encouraged to do personal research on the subjects of solar activity, ionospheric properties, radio propagation and geophysical activity. Research in these areas will significantly enhance ones understanding and ability to interpret and apply the information contained in the publicized reports, alerts and warnings.

2. The Solar Terrestrial Forecast and Review

This report is the primary report of solar and geophysical activity. It includes enough information and data to be of use to many people involved in radio communications, solar physics and geophysics. It is issued once a week and contains summaries and forecasts for the next 10 to 20 days.

The report itself is compiled from raw data obtained from several sources. One of the major sources is the Space Environment Services Center (SESC), which serves as a major global data-collection center for space-related environmental data. The SESC is responsible for the solar terrestrial information which is posted on radio stations WWV and WWVH at 18 minutes past each hour.

The data obtained from the various sources are all collected and analyzed by before being compiled into the reports which are publicly posted. Computer models, coronal maps and recurrent patterns are all examined and analyzed. The results are incorporated into the various forecasts in the reports. The actual prediction methods are beyond the scope of this paper.

In this section, we will begin a systematic analysis of the various sections of the Solar Terrestrial Forecast and Review. Some of the terms contained herein may not be clearly defined. For those terms which are unclear, the interested reader is encouraged to consult the "Glossary of Solar Terrestrial Terms", published in our May 1992 issue.

2.1. Summary of Solar Terrestrial Activity

This section of the report summarizes the highlights of solar and geomagnetic activity which took place over the preceding week. Solar activity is given first, followed by a summary of geomagnetic and auroral activity. Following this, a summary of the HF and VHF propagation conditions for the preceding week are given. Any particularly severe solar or terrestrial activity will be given special treatment in this section.

Basically, the summary of solar activity includes a discussion of those regions on the sun which exhibited abnormal signs of activity. This may include a description of major solar flares, noteworthy filament disappearances, or unusually large coronal holes. It may also include a description of various unusual or impressive forms of limb-activity such as prominences, plage or faculae activity, or limb surges or flares.

In all of the solar summaries, references will be made to specific regions postfixed with specific numbers (i.e., Region 6354). These "region numbers" are simply sequential numbers assigned to active regions as they appear or are identified. The numbering of these regions was started by the SESC many years ago. The first region to be assigned was given a region number of 1. Consecutively identified regions were given numbers of 2, 3, 4 and so on. Each new region is given the next consecutive region number.

In order for a region to be assigned a region number, it must qualify according to one of the following criteria: (1) If the region has a sunspot group which has a first-position type-classification of C, D, E, F or H, it will be given a region number (see the "Glossary of Solar Terrestrial Terms for a description of the sunspot classification scheme). (2) If two or more reports confirm the presence of class A or B spots (again, see the above-referenced document), it will be given a region number. (3) If the region produces a solar flare, it will be given a region number. (4) If the region is "bright" in H-alpha light and exceeds 5 heliographic degrees in either latitude or longitude, it will be given a region number. These four criteria are used in determining what areas are assigned solar region numbers by the SESC and which areas are not.

The vast majority of solar summaries include statements regarding the intensity (or class) of specific flare events. Flares are categorized using two types of classifications. The first method categorizes a flare with regards to its output energy at X-ray wavelengths measured by orbiting satellites. The second method categorizes flares according to their size and brightness at optical wavelengths (observed using monochromatic H-alpha light filters).

Both of these flare classifications are described fully in the "Glossary of Solar Terrestrial Terms." Refer to it for more information.

The positions of all solar regions and events are given according to the format: AxxByy, where xx represents a latitude (in degrees), "A" represents either the "N" (North) or "S" (South) solar hemisphere, "yy" represents the solar longitude given in degrees east or west of the central solar meridian, and "B" represents either "E" (East) or "W" (West) of this central meridian (ex. N26E72). The exact center of the visible sun represents the origin where the longitude is measured from. The extreme limbs of the solar disk represent longitudes of 90° (either East or West, depending on which limb you look at), while the extreme poles of the sun represent 90° latitude (either North or South, again depending on which hemisphere is observed).

It should be noted that the orbit of the earth carries us slightly above and below the sun's rotational equator. During six months of the year, we are above the northern portion of the solar equator, while during the next six months, we fall below the southern portion of the solar equator. Near the equinoctial periods (spring and fall), our orbit places us at our maximum distance above or below the solar equator. If, at these times of the year, the earth were moved in a straight line toward the center of the sun, the earth would make contact with the sun's surface at a latitude of about 7.3° with respect to the solar equator. Although these periods do not exactly coincide with the each equinox (i.e., maximum southerly extent is achieved on 07 March, while maximum northerly extent is reached on 09 September), they do coincide within a month of the equinox.

These latitudinal changes are important, since they alter the way we must observe the sun. During the equinox periods, the center of the sun as we see it is actually about 7° to the north or south of the actual solar equator. If this were not taken into account, the measured positions of sunspots and other surface features would be grossly in error.

The important point to remember when studying the positions of sunspot groups is that the coordinates given represent the position of the sunspots relative to the rotation axis of the sun as viewed from earth. For example, a sunspot group located at a position of N21E62 represents a position 21° north of the solar equator, and 62° east of the solar central meridian (or 28° away from the eastern limb [$90 - 62 = 28$]).

Since the sun rotates from east to west, all sunspot groups and other observed features rotate in the same direction. More specifically, the sunspots rotate at an average speed of about 13° per day. So the sunspot group located at N21E62 would be located at N21E49 the following day, and N21E36 the day after that. They may also occasionally drift in latitude, although the drift in latitude is negligible most of the time.

Following the solar summary, the summary for geophysical and auroral activity is presented. These summaries should be mostly self-explanatory with the exception of possible notes regarding magnetic fluctuations.

In summaries of particularly intense magnetic activity, statements may be made regarding the maximum intensity of some of the magnetic fluctuations observed during the period being reviewed. These summaries will generally

involve the terms nanoTesla and/or gamma, which are synonymous. The intensity of magnetic fluctuations are latitude-dependent. Higher latitudes naturally experience more intense magnetic fluctuations than the lower latitudes. Southerly middle latitude regions consider magnetic fluctuations of 500 nanoTesla (nT) to be very severe, while high latitudes may consider fluctuations of 2500 nT to be very severe. The magnetic A and K indices have been developed to aid in equating the intensity of magnetic fluctuations over wide latitudes. For example, a magnetic fluctuation at Anchorage Alaska may be considered to be as "equally intense" as a similar fluctuation in California if the A or K-indices for both locations are equal, even though the actual magnitude of the fluctuations at Anchorage are much higher than the corresponding fluctuations in California. A K-index of 4 at Yellowknife in northern Canada may correspond to a magnetic fluctuation of 160 nT, while a K index value of 4 at Boulder Colorado may correspond to an actual magnetic fluctuation of only 50 nT. Both fluctuations may be considered equally severe based on how often fluctuations of that magnitude are usually encountered for that latitude. Yellowknife may encounter fluctuations of 50 nT on a daily basis whereas Boulder may not encounter magnetic fluctuations of that magnitude for weeks. Hence the need for indices which can equalize the latitudinal dependencies.

Notes of auroral activity in the review section of the report are generally limited to descriptions as described in the Glossary of Solar Terrestrial Terms. However, for extraordinary events such as occur during auroral storms, a more detailed examination of auroral activity may be given. Such descriptions may include auroral types, color fluctuations, pulsations or movement patterns of auroral forms. All of these descriptions are contained in the Glossary mentioned above and part I of this document.

Notes regarding HF and VHF propagation are usually confined to brief accounts of overall global conditions. These conditions are generally rated as either above normal, normal, below normal or very poor. Above normal propagation indicates strong signals which are abnormally stable. Above normal propagation is most often associated with good to very good DX potentials. Normal propagation denotes normal conditions after considering the season and the position within the sunspot cycle. It is compared with the average conditions experienced over previous seasons and solar cycles. Below normal propagation is usually associated with increased geomagnetic activity and is more consistent with signals of lower quality, less stability, and weaker strengths. Chances for DX drop noticeably during periods of below normal propagation, except for the VHF bands where an increase in DX may actually occur. Very poor propagation is most often associated with magnetic storms or PCA events where signal absorption, fading and instability dramatically affect the quality of signals. During intense storms, localized blackout conditions may occur. This term may be used in these instances to denote exceedingly high signal absorption levels. Again, the exception is VHF frequencies, where long-distance communications often improves during periods of high HF absorption or blackout periods. However, the quality of the VHF signals may be quite poor despite the enhanced communication range.

2.2. Short Term Solar Terrestrial Forecast

This section of the report follows the same basic structure as the review described in the last section, except that predictions are given instead of reviews. The predictions are made using the same methods described in the

preceding sections, but are translated from tables and charts into sentence form.

This short-term prediction section is intended to point out the highlights which can be expected over the coming week. Overall global conditions are given in this section of the report. Therefore, the person interested in radio communications or auroral activity should keep in mind the nature of this section. It is not intended to list the possible localized phenomena which might occur. Just the general overall global conditions are stated.

The short term forecasts should be used as a guide only. The art of predicting geomagnetic storms and major flares is by no means an easy process. There are many variables which are unknown and processes which are not fully understood yet. Although we have made great advancements in the fields of solar physics and geophysics, we have a long way to go in the area of predictions. The forecasts presented in these reports may therefore be in error at times. They are, however, based on the most current models and the most recent data.

2.3. Solar Region Summary

The summary of solar regions is the section of the report which is in tabular form and includes the region numbers, sunspot sizes, sunspot classes, angular extents, magnetic configuration, etc. This section is of great value to those who are tracking sunspot groups or watching for signs of growth or increased magnetic complexity and/or flaring.

Although each of the aspects of this table are described in the Glossary of Solar Terrestrial Terms, we will elaborate on some of the more vague terms of in this section.

Each solar region is given a number and its position on the solar disk is measured (as was described above). This identifies and defines the exact position of a solar region on the sun. The positional description (i.e., the latitude/longitude description) is relative to the hemisphere of the sun which is in view. That is, the longitude of a solar region is relative to the center of rotation as seen from the earth. This places the 00° longitude (i.e., the central meridian) continuously at the center of the sun (in a line stretching from the north solar pole through the center of the disk as observed from the earth, to the south solar pole). All of the solar regions rotate while the longitudinal lines remain stationary. This method of marking positions of sunspots and other phenomena is very adequate, but fails to describe the position of sunspots on a solar global basis with respect to a fixed 360° longitudinal system (as is employed for the Earth).

In order to solve this problem, a system was developed to begin mapping active regions on a fixed solar geographical basis. The actual longitudinal position of sunspots are therefore recorded in two different ways. The first way (described in the preceding sections) enables us to determine how far away a solar region is from the central meridian. It effectively separates the observable solar disk into an east and a west hemisphere with the dividing line coinciding with the central solar meridian. The second method is analogous to the way we have mapped the Earth, with fixed lines of longitude dividing up the entire sphere.

The figures in the region summary under the heading "LO" represent this second mapping method. This second method is useful in determining the movement of a sunspot

region compared to the flow of gases around the sunspot region. Sometimes, sunspots will move slightly slower than the gases around the spot, which will gradually cause the longitudinal location of the sunspot to change. Sometimes, they move faster than the gases normally do at that location. So by observing these longitudinal values, you can determine whether a sunspot is moving faster or slower than usual.

This method of referencing sunspots is also useful in identifying regions of the sun which are abnormally active. During the years of maximum solar activity, the sun often exhibits longitudinal regions which are more active than other longitudes. During solar maximum years, there are often two areas of abnormal activity separated by about 180°. By observing the positions of sunspots using this method of mapping, the active solar longitudes can be discovered. This is valuable for those who want to forecast solar activity. Likewise, some solar longitudes are often regions of enhanced corpuscular emissions (i.e., regions where matter is ejected from the sun), which can significantly affect radio communications and geomagnetic activity. Plotting the positions of these active longitudes can also be of tre, there are often two areas of abnormal activity separated by about 180°. By observing the positions of sunspots using thmendous aid in predicting recurrent storms or periods of increased geophysical activity.

The column in the table labeled "Z" represents an optical classification scheme for sunspots and sunspot groups. The details of this classification method are given in the Glossary of Solar Terrestrial Terms. The interested reader is directed to consult this document for more information. It categorizes the optical shape and complexity of sunspot groups.

The column labeled "LL" represents the angular extent of the sunspot group. Angular extent is given in solar degrees. Comparing this value with the number of spots within the region (denoted by the "NN" column of the table) yields the density of the group. The density is important because it is an indirect measure of the gradients of magnetic fields within the region. High gradients produce more frequent and more severe solar flares, while weak gradients are usually associated with less-compact spot groups which produce less severe and less frequent flares.

The "MAG TYPE" or magnetic-type of sunspot groups as noted in the last column of the table can also be used to determine the magnetic complexity and magnetic gradients within active regions. Consult the Glossary mentioned above for more information regarding these classifications.

In addition to details on spot groups, this region of the report also enumerates those areas which are not associated with sunspots, but contain areas of enhanced H-alpha plages. These regions are assigned region numbers according to the rules noted above. These regions are often the sites for sunspot formation. They may also be associated with old regions which are decaying.

2.4. Geomagnetic Activity Summary

Following the solar region summary, a graphical analysis of recent geomagnetic activity is presented. This graphical table charts planetary geomagnetic activity as it is recorded for many magnetic observatories around the world. It includes recent data for the last 96 hours up to the time the report was compiled. The use of planetary geo-

magnetic activity gives a good indication of global activity from the high latitudes to the low latitudes.

This chart has been constructed from each of the 3-hourly K-index values reported by all of the participating magnetic observatories. Each graph line, therefore, represents a 3-hour period of time. The time on this graph is in Universal Time (relative from Greenwich, England). Therefore, the first graph line of this chart represents the activity occurring from 00 UT to 03 UT (actually, from 00 UT to 02:59:59 UT). The second line represents activity occurring from 03 UT to 06 UT, and so on.

The left-hand side of the chart relates the levels of geomagnetic activity to the approximate corresponding severity of activity. This activity is defined from "Very Quiet" levels, which corresponds to magnetic K-indices of zero, to "Extremely Severe" levels which corresponds to magnetic K-indices of about nine.

The right-hand side of this chart serves as a very rough guide to the potential severity of magnetic-induction that might be experienced during corresponding levels of magnetic activity. By "magnetic induction," we mean the severity of magnetic fluctuations necessary to begin influencing ground-based systems such as electrical powerline systems, telecommunications systems, pipeline networks, etc. This end of the chart is not intended to be a definitive classification, but rather is only meant to serve as a potential indicator to possible magnetic-induction. There are a great many variables that must be taken into account before magnetic fluctuations can be qualitatively classified as capable of inducing electrical currents into groundbased systems. These variables are not considered in this chart. Only the general level of magnetic fluctuations are considered and are related to possible magnetic induction. Such localized parameters as air-earth conductivity, ionospheric current system parameters, electrical field configuration, ground resistivity, and ground-based system network configurations must be considered (among other things) before true hazards regarding magnetic induction can be determined. Therefore, this area of the chart should be used only as a very rough guide. Nothing more and nothing less. It should be noted, however, that magnetic fluctuations rated as K-indices greater than 6 generally become capable of wide-spread electrical current induction. Storms with fluctuations this high are usually capable of influencing ground-based systems over wide areas.

The geomagnetic activity graphed in this chart represents the peak global magnetic activity observed during the respective periods. It does not represent average magnetic activity. This is important to realize. These K-index values are not the same values reported on radio stations WWV and WWVH. The values reported by these stations represent the magnetic activity occurring at Boulder, Colorado. Since this chart is derived from measurements of geomagnetic activity around the world (not at one specific location), the planetary values are more valuable and applicable on a global scale.

2.5. 10-Day Geomagnetic Activity Forecast

This chart graphs the expected levels of planetary geomagnetic activity over a 10-day period. Each day is separated into three 8-hour segments. Each line of the chart therefore represents one eight hour interval of time. This chart graphs expected conditions relative to Universal Time. That is, the first line after each date dividing line represents expected conditions between 00 UT and 08 UT for that day. The middle graph line represents conditions

expected between 08 UT and 16 UT. The last graph line for each day in the chart represents the magnetic activity that is expected from 16 UT to 24 UT. This chart should be more easily interpreted than the previous geomagnetic activity summary chart. It is certainly more valuable.

The predictions are based primarily on data regarding coronal holes, potential recurrent activity, diurnal trends and potential solar activity influences. The transient solar component (ex. major flares) are not included as part of this prediction, since flaring is extremely unpredictable and forecasts of potential major flaring in excess of a day or two is very unreliable.

2.6. Graphical Analysis of Solar Activity

The graphical chart summarizing solar activity is produced each week for a 60-day period. This period covers two complete solar rotations and is sufficient to show the cyclic behavior of solar activity from one cycle to another.

The solar flux (the intensity of solar radio noise observed at 10.7 cm wavelengths) is plotted in this graphical analysis. The solar flux represents the slowly varying component of the sun (see part I) and is strongly correlated with the number and intensity of sunspot groups on the solar surface. The higher the number of sunspots visible, the higher the solar flux. As sunspots disappear behind the western solar limb, the solar flux decreases. The 10.7 cm solar radio flux is therefore a good indicator of the overall state of the observed solar environment.

Under normal conditions, the plot lines for the solar flux are plotted using asterisks (*). However, on days when major flares erupt, these plot lines are changed from asterisks to "F"s. This enables readers to determine the period during the rotational cycle of the sun when major flares occurred. In most cases, it will be observed that most of the major flare activity occurs during the rotational peak of each cycle. There are, however, exceptions to this, as will occasionally be noted.

Plot lines are only changed from asterisks to F's when major flares erupt which meet or exceed an X-ray intensity of class M5.0. A flare of class M4.9 may be a fairly major event, but is not considered a major class flare since it never reached M5.0 class intensities. Most flares, however, are either above or notably below this limit. There are many more flares of class M3.0 intensity than there are flares of class M4.0 intensity. Most major flares, therefore, are observed to occur above this M5.0 transition level. Very few are borderline cases.

(To be continued)

On tap for the next "catch-up" issues are (1) the conclusion of Cary Oler's tutorial on Understanding Solar-Terrestrial Reports, (2) graphs showing just how the sun (and earth's ionosphere) did during 1992, (3) a report on the decline of ionospheric sounding, all with graphs, tables, and other implements of enlightenment.

Hey, we want you to compare these Solar-Terrestrial parameters with how you did! Is there correlation or not?

Since we have three more 1992 issues to catch up, we welcome reports of any VHF propagation during Fall 1992 that were not covered in our 1993 January 15 issue. Send reports and comments to: Victor Frank, K6FV, 12450 Skyline Blvd., Woodside, CA, 94062-4541